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(54) **RIGID PISTON VALVE INCORPORATING A SOLENOID**

(71) Applicant: **SDB IP Holdings, LLC**, Oviedo, FL (US)

(72) Inventors: **Shawn D. Bush**, Winter Park, FL (US); **Ryan W. Nottage**, Marietta, GA (US)

(73) Assignee: **SDB IP Holdings, LLC**, Oviedo, FL (US)

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(51) **Int. Cl.**

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F16K 3/24	(2006.01)
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E03D 5/09	(2006.01)
E03D 5/10	(2006.01)
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CPC ***F16K 27/041*** (2013.01); ***B23P 6/00*** (2013.01); ***E03D 1/34*** (2013.01); ***E03D 3/04*** (2013.01); ***E03D 5/09*** (2013.01); ***E03D 5/10*** (2013.01); ***F16K 3/0218*** (2013.01); ***F16K 3/0254*** (2013.01); ***F16K 3/243*** (2013.01); ***F16K 31/0644*** (2013.01); ***F16K 31/3835*** (2013.01); ***F16K 31/406*** (2013.01); ***F16K 31/60*** (2013.01); *Y10T 29/49407* (2015.01)

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USPC .... 251/40, 33, 37, 58; 92/103 F, 103 M

See application file for complete search history.

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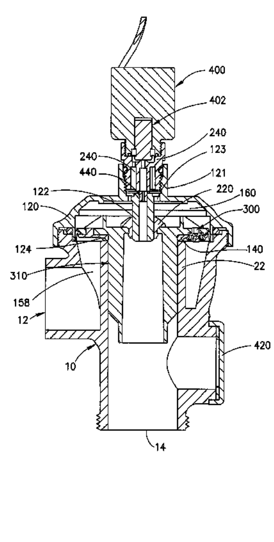
Primary Examiner — Umashankar Venkatesan

(74) *Attorney, Agent, or Firm* — The Webb Law Firm

(57) **ABSTRACT**

A rigid piston assembly for use in a conventional flush valve includes a rigid piston and a solenoid configured to fixedly engage within the valve body. A flush valve for a plumbing fixture as well as a method of retrofitting a piston valve into a diaphragm flush valve body which includes a rigid piston and solenoid configuration.

20 Claims, 12 Drawing Sheets



(51) **Int. Cl.**

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F16K 31/60	(2006.01)

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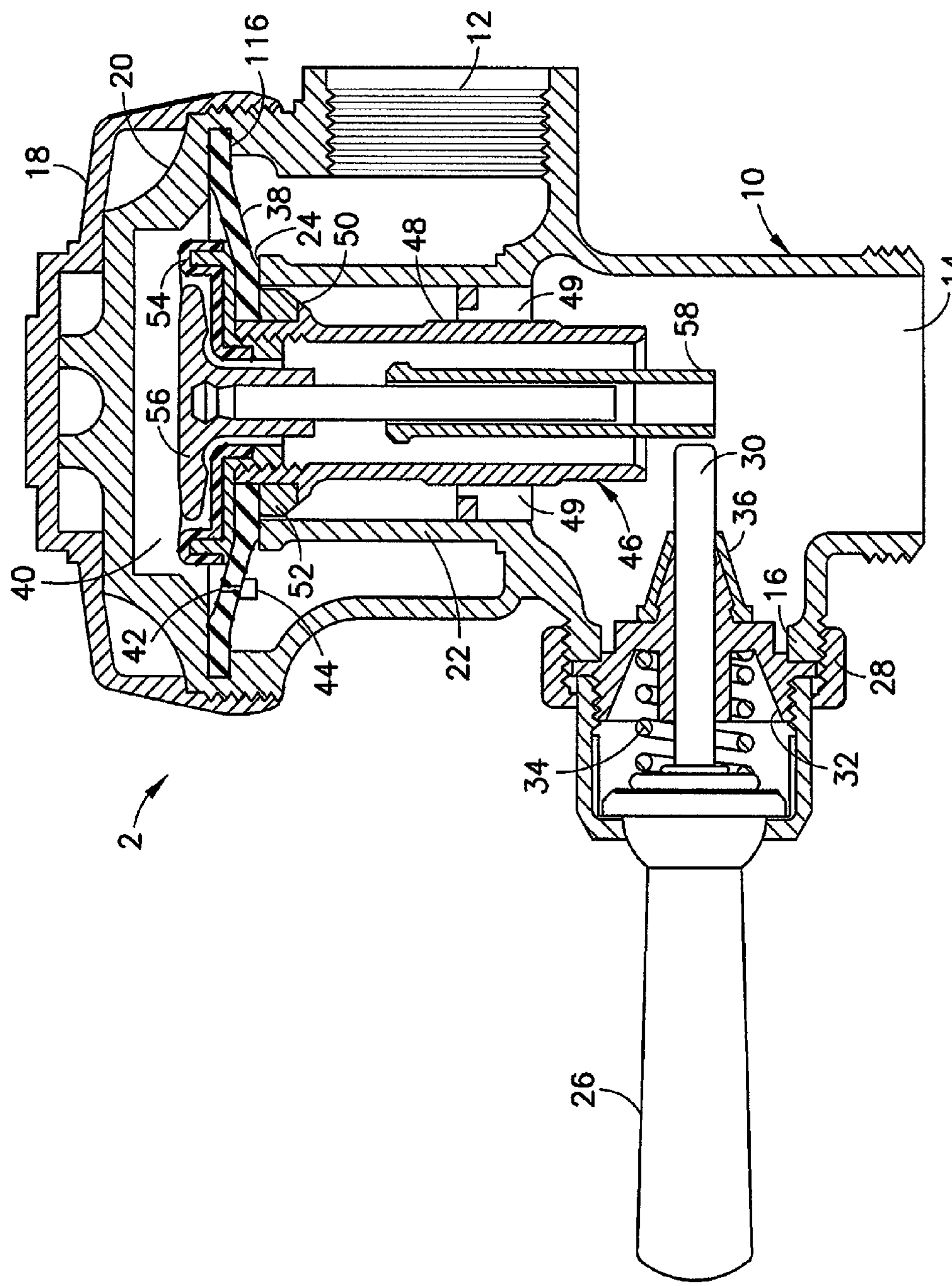

FIG.1
PRIOR ART

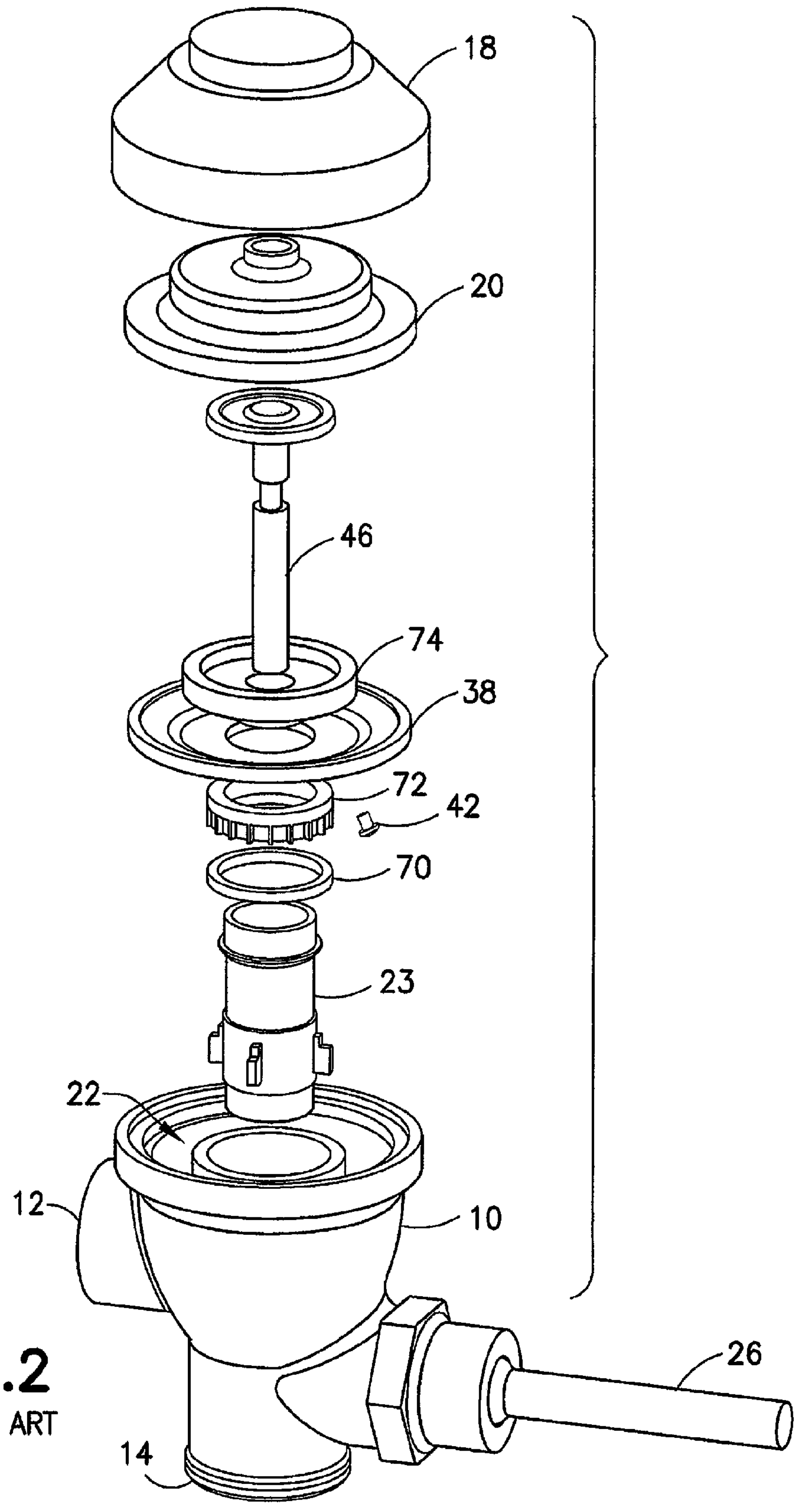

FIG.2
PRIOR ART

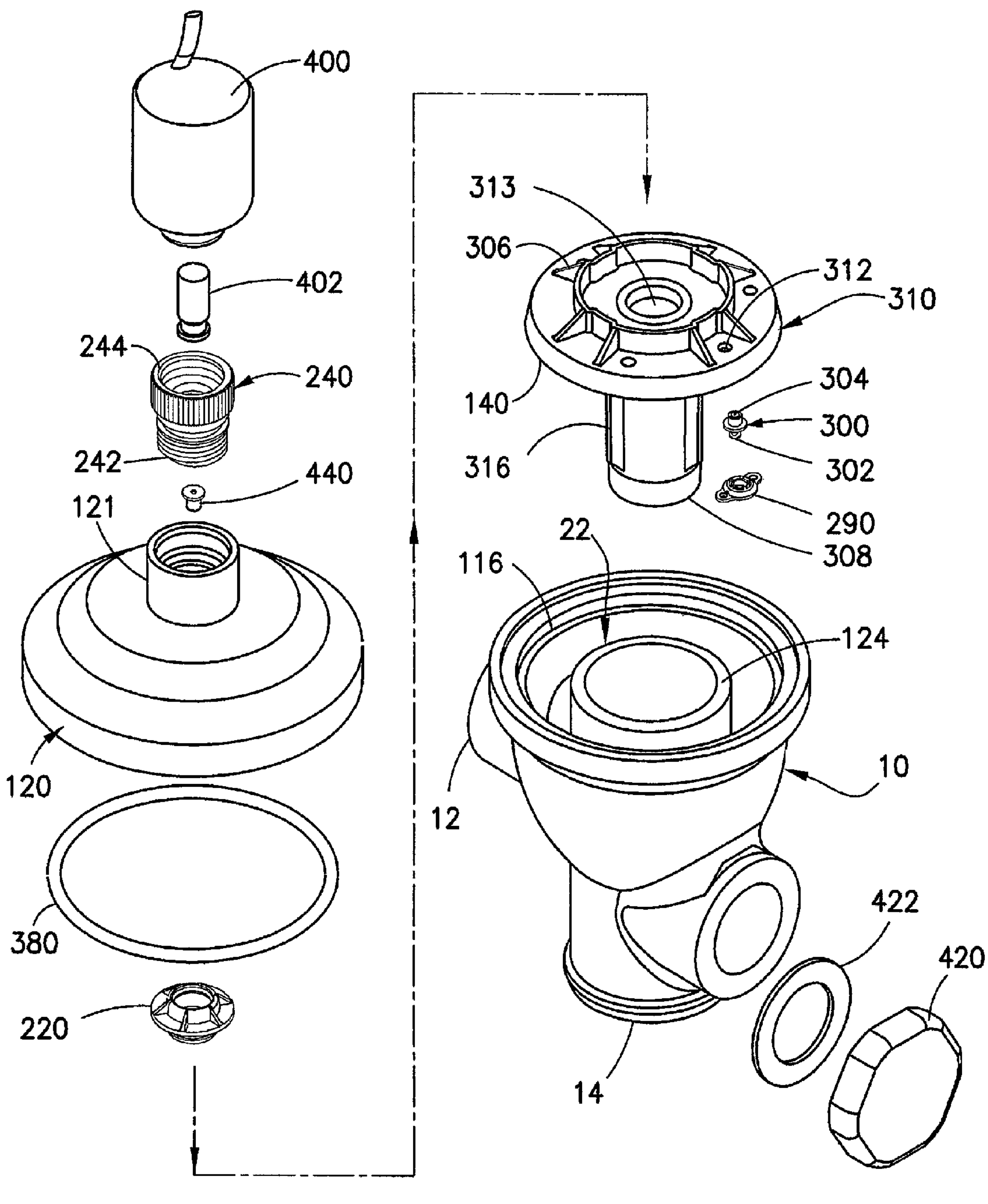
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FIG.3

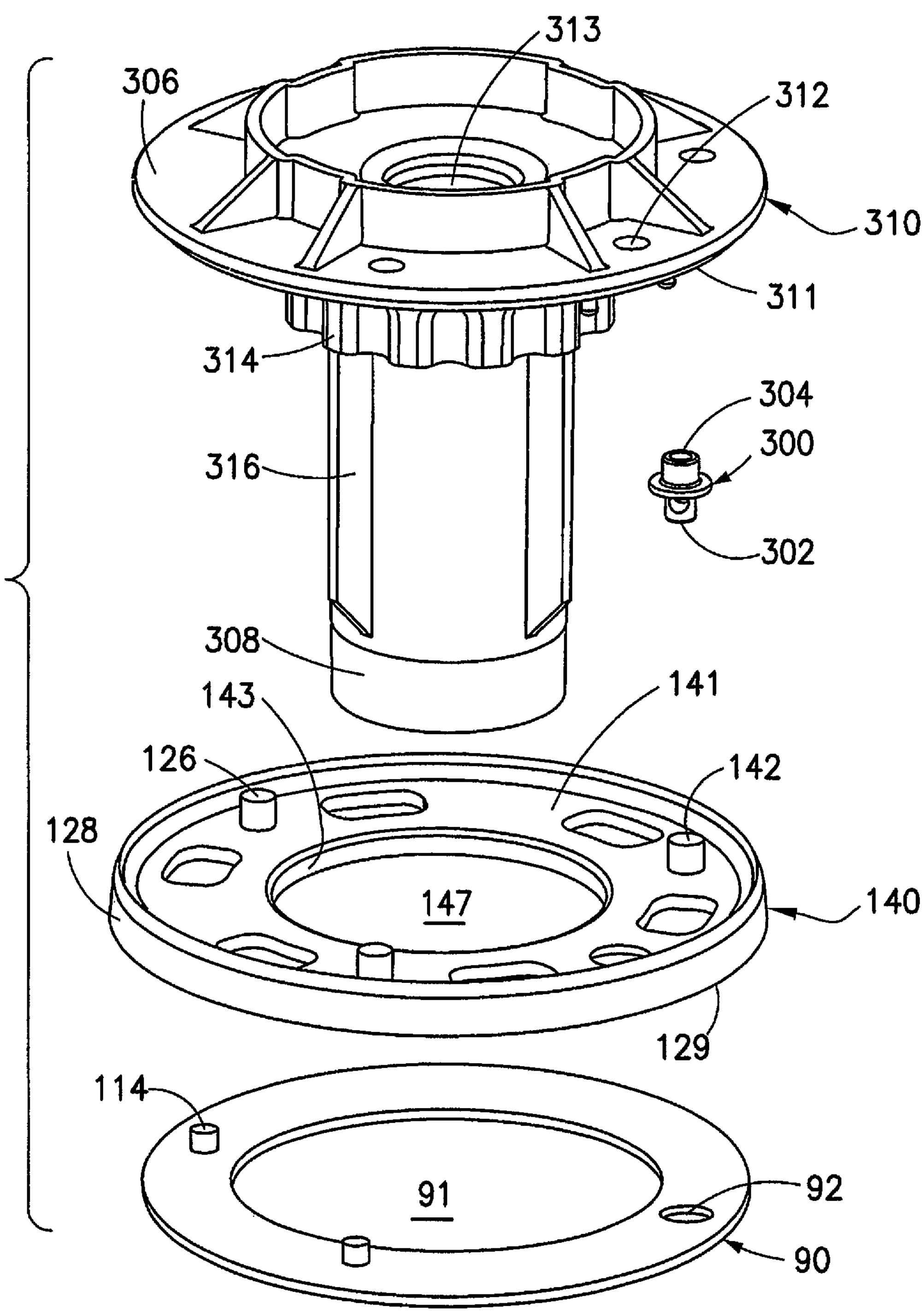
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FIG.4

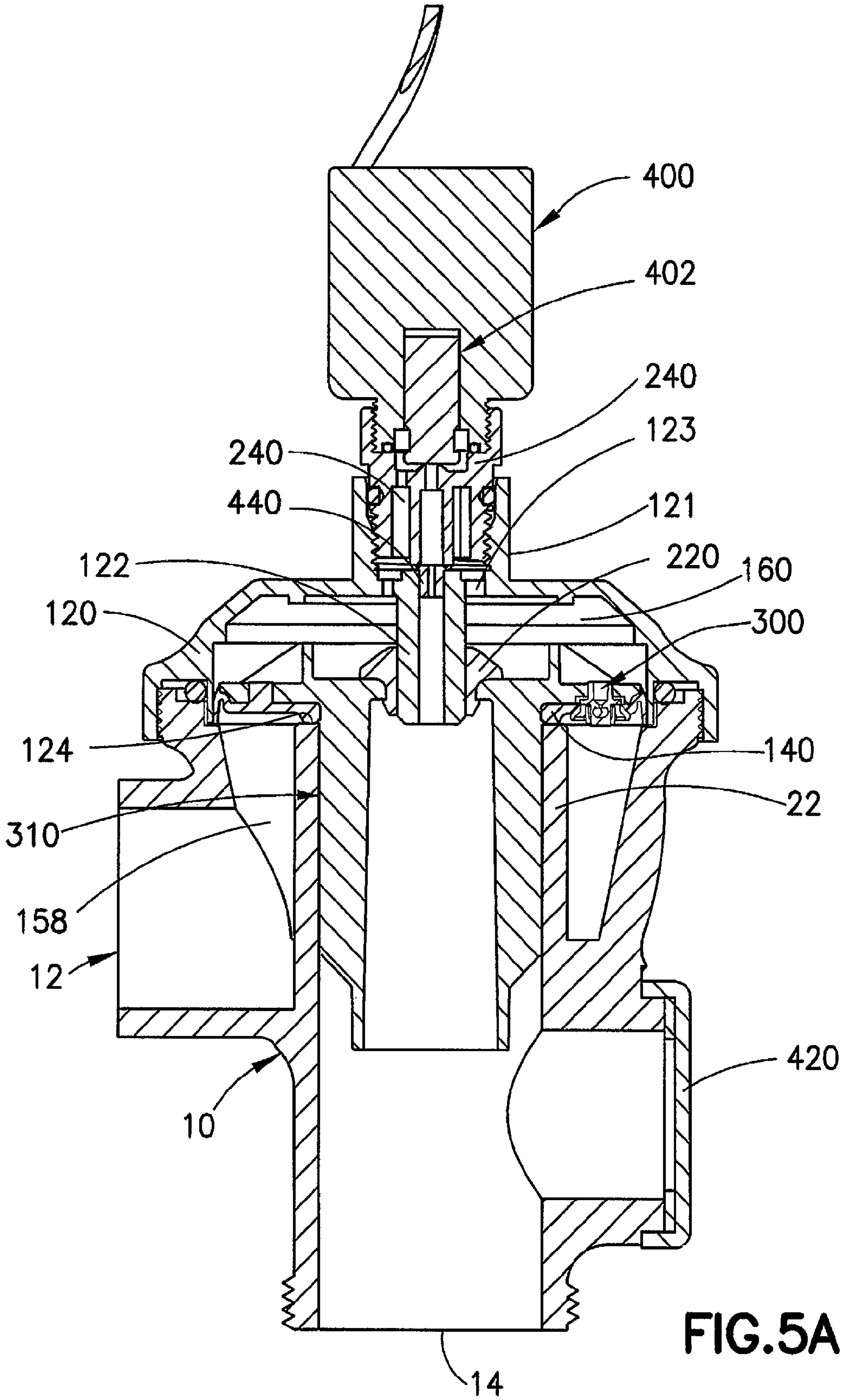
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FIG.5A

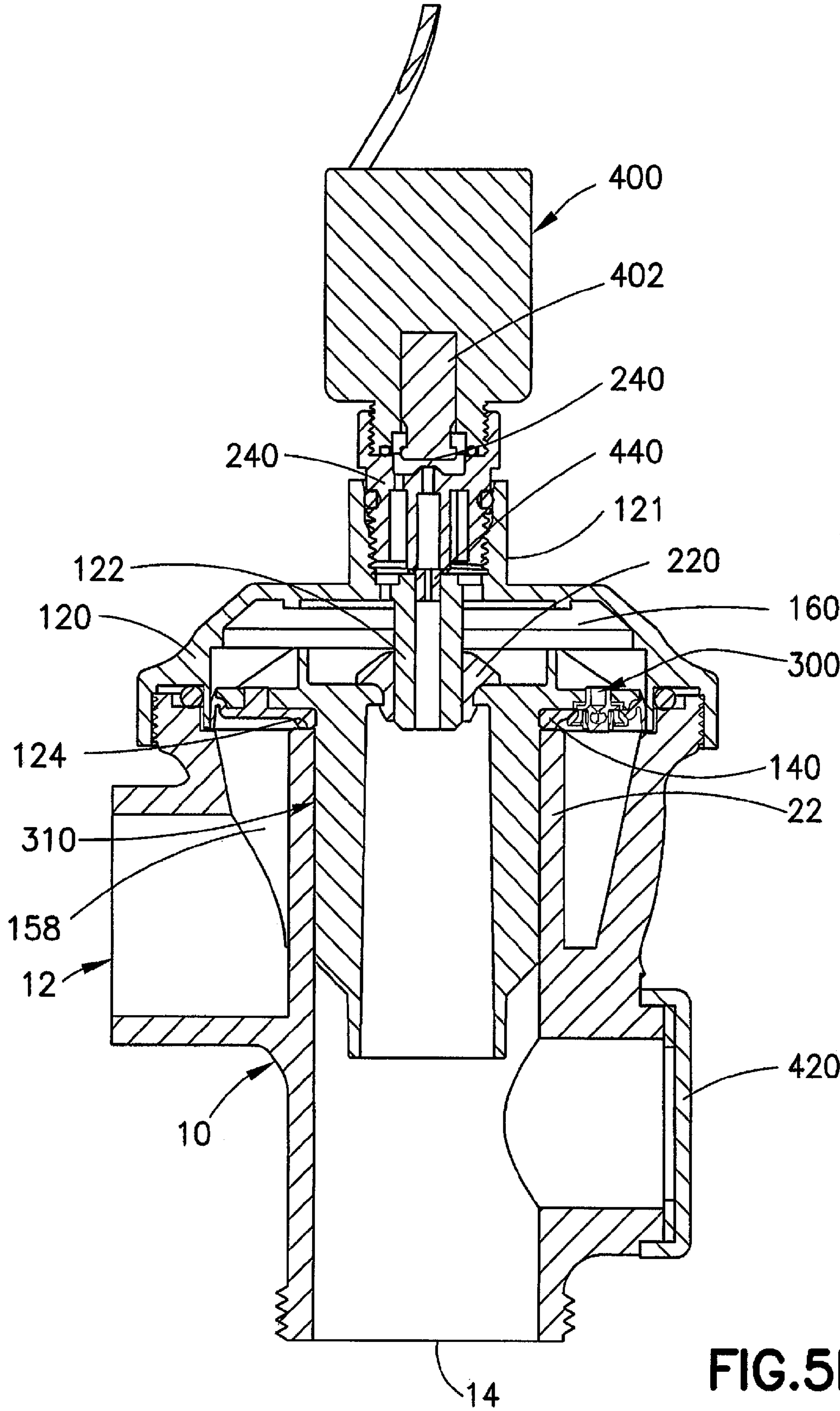
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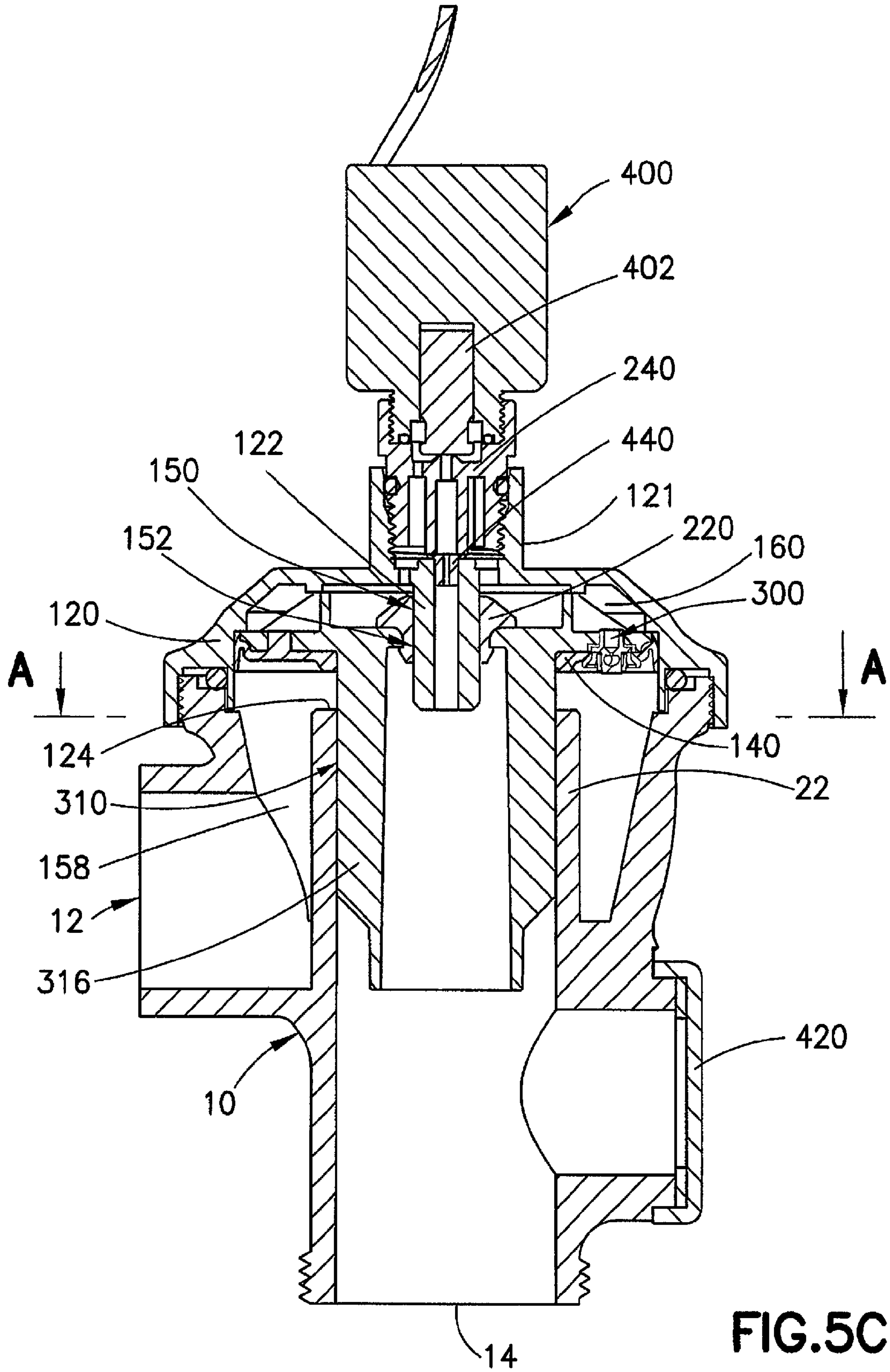
FIG.5B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10
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FIG.5C

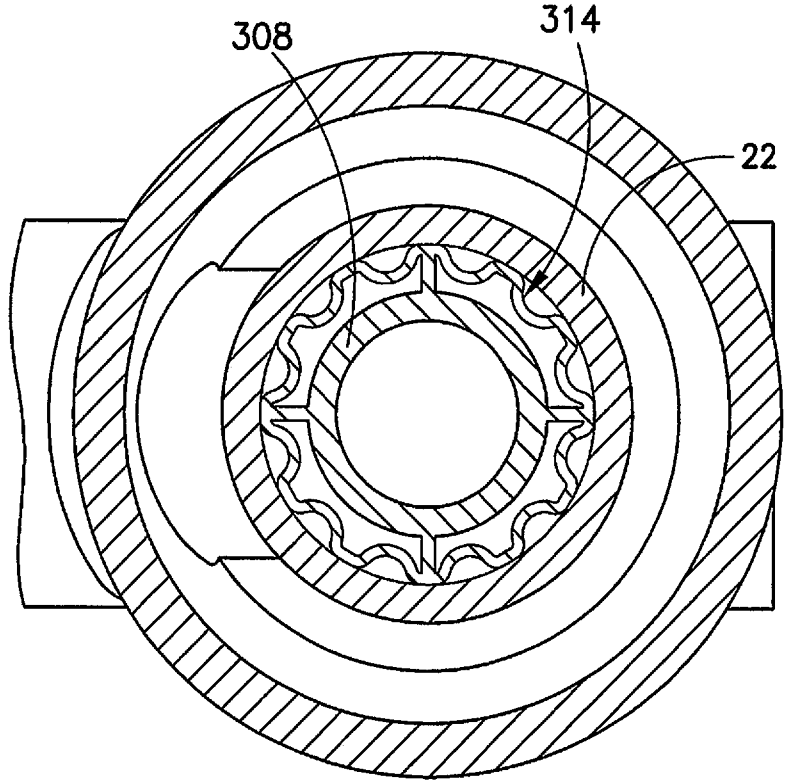

FIG.6

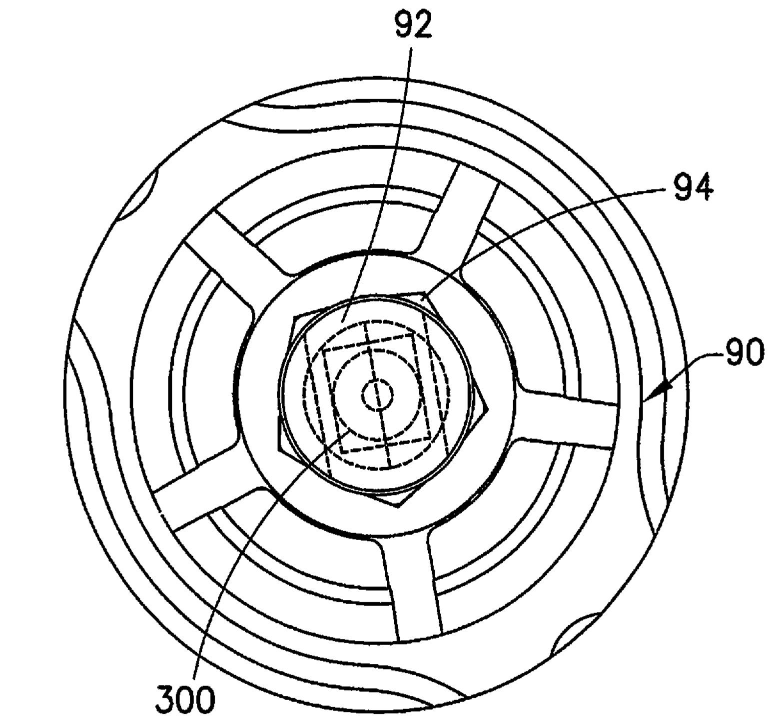

FIG.7

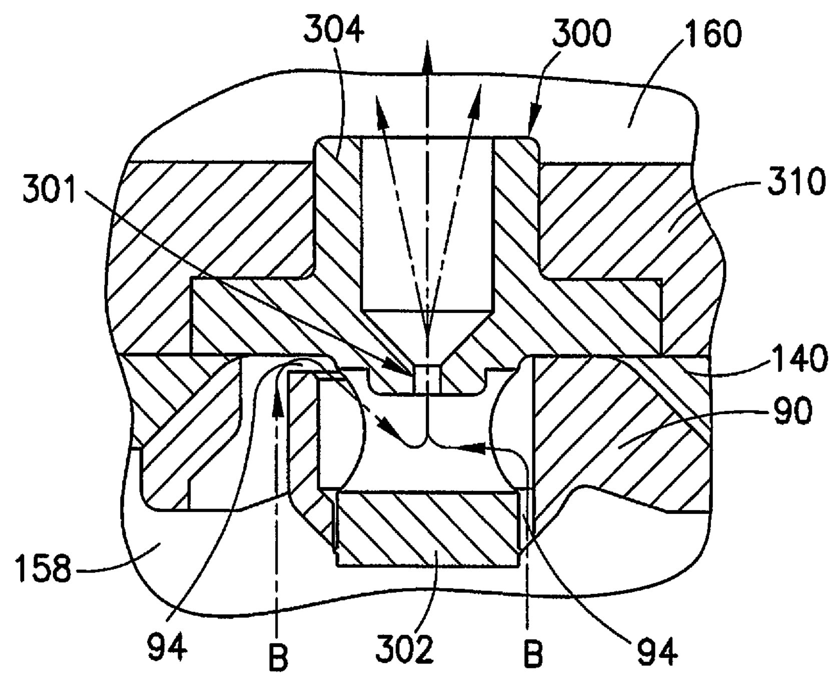

FIG.8

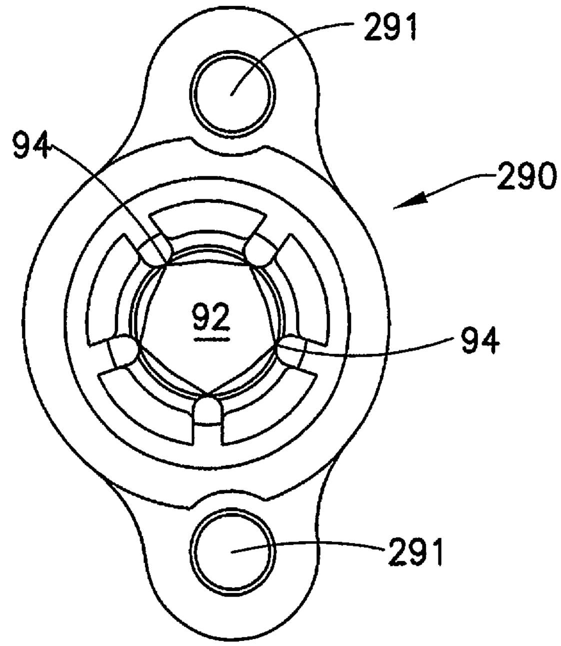

FIG.9

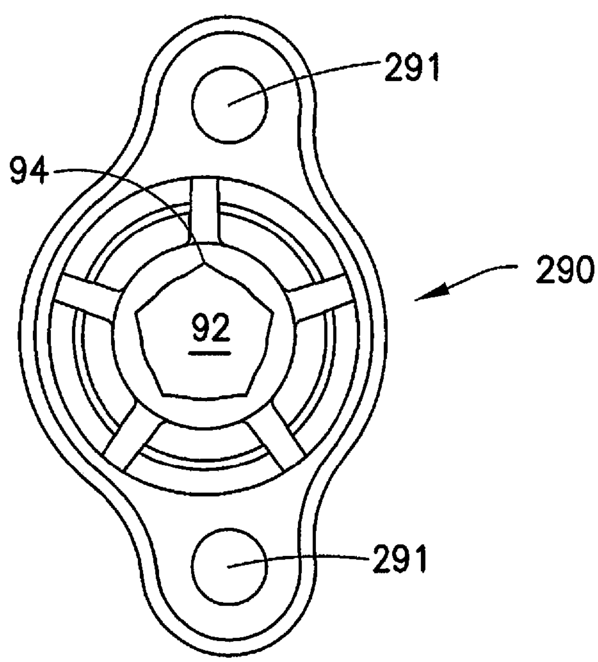

FIG.10

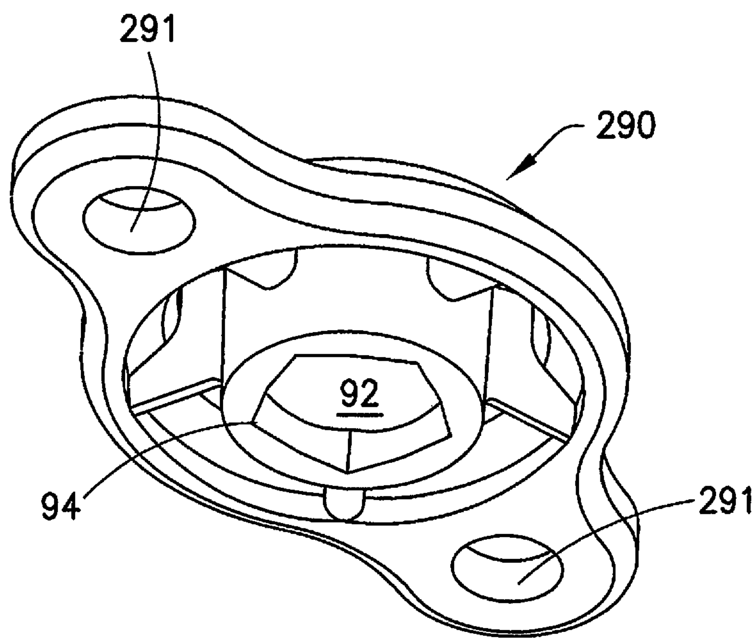

FIG.11

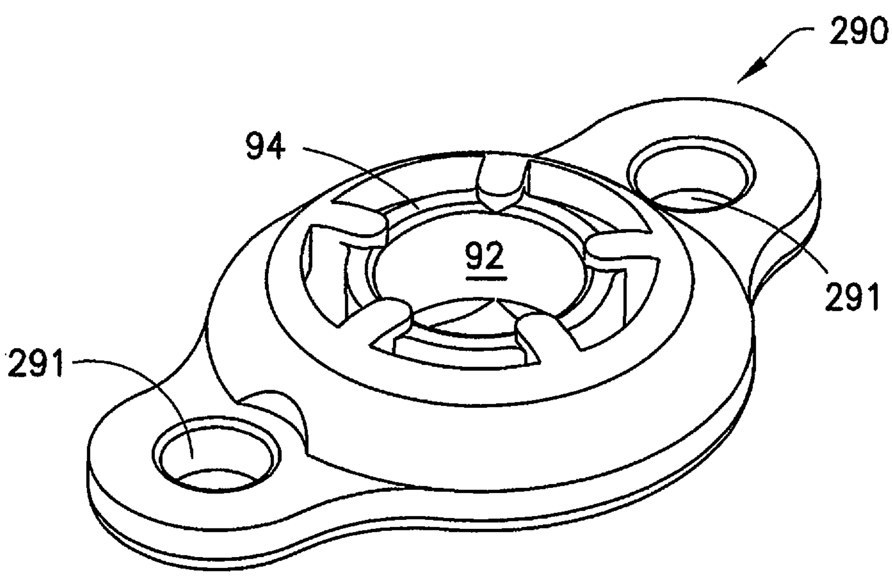

FIG.12

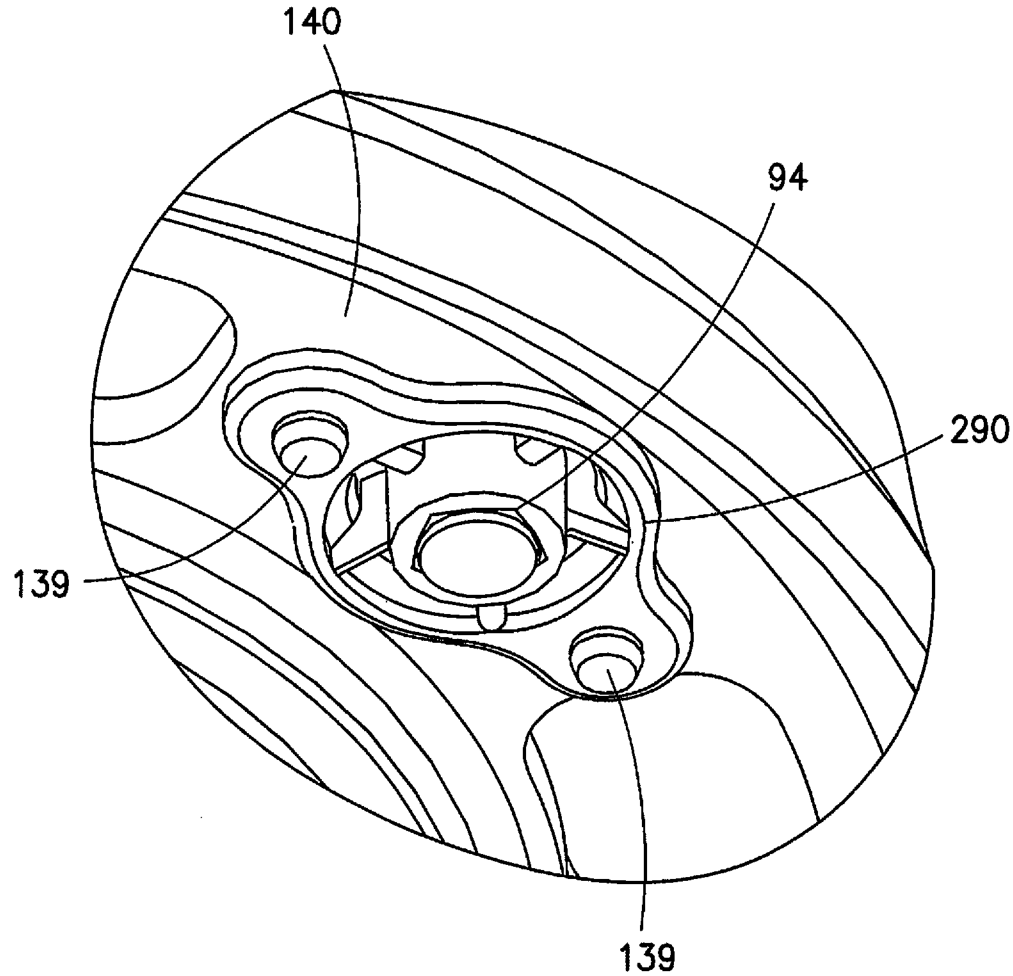

FIG.13

RIGID PISTON VALVE INCORPORATING A SOLENOID

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/955,567, filed Dec. 1, 2015, which is a continuation of U.S. patent application Ser. No. 13/866,550, filed Apr. 19, 2013, now U.S. Pat. No. 9,228,662, which claims the benefit of U.S. Provisional Patent Application No. 61/636,174 filed on Apr. 20, 2012, the entire disclosures of each of which are hereby incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to flush valves and, in particular, to a rigid piston with a solenoid for use in a flush valve.

Description of Related Art

Valves are used throughout many fluid transfer systems and in various applications, such as in the transfer and control of water conduit systems, and, in particular, in connection with plumbing fixtures in both residential and commercial settings. For example, flush valves are typically used for control and operation of toilets, urinals, and the like, such that when a user actuates a handle, water flows through the flush valve into a basin portion and out the drain.

A common type of flush valve is a diaphragm flush valve. Such a diaphragm flush valve is disclosed in U.S. Pat. No. 4,327,891 to Allen et al., herein incorporated by reference. The Allen patent discloses the use of a diaphragm in a flush valve, where the diaphragm is made of molded rubber and serves to effectuate the flow of water from a water inlet, through the valve, and to a water outlet. Further, the Allen patent sets forth various components and sub-components of a conventional flush valve.

Such diaphragm flush valves have several drawbacks. For example, the relatively small by-pass orifice positioned in the diaphragm can become clogged with debris, which prevents water from flowing into an upper chamber located in the flush valve. This causes the flush valve to remain open, resulting in constant water flow. In addition, the flushing cycle of the diaphragm flush valve takes approximately seven seconds to complete, depending upon the flow rates and pressure of the water entering the valve, due to the design of the diaphragm of the flush valve. Since an upper chamber fills slowly, the valve is slowly "shutting off". Therefore, a significant amount of water is wasted through the trap and sewer line during the sealing process of the valve. Yet another drawback is that conventional diaphragm flush valves are impacted at water pressures below 35 psi, since sealing of the valve based on the water pressure against the diaphragm is difficult with such lower water pressure. A need, therefore, exists for a valve replacement element that can effectively be retrofitted into a flush valve that does not have the drawbacks associated with conventional diaphragm flush valves. A further need exists for a flush valve having improved sealing features. Further still, it would be desirable to incorporate a solenoid into the flush valve for electronic operation.

SUMMARY OF THE INVENTION

In accordance with one embodiment, a rigid piston assembly is used as a replacement element in a flush valve having a valve body with a fluid inlet, a fluid outlet, an outer cover, and a handle member. The rigid piston assembly includes a rigid piston with a central opening and a by-pass orifice. The rigid piston is mounted within the valve body. The rigid piston can further include guide members that maintain the alignment of the rigid piston within the valve during operation as well as a flow ring that gauges the amount of water to be flushed during operation.

An adapter may be attached to the central opening of the rigid piston. A cap may be connected to the valve body at an end opposite the fluid outlet. The cap may have a hollow stem that extends from a central opening in the cap. The hollow stem can engage the adapter. A sealing component may be placed into the valve body forming a seal between the cap and the valve body.

A piston seal having a by-pass orifice can be fixedly engaged to the rigid piston and sealingly engaged to the valve body near an entrance of the fluid outlet. The piston seal can have an annular skirt that is adapted to extend out toward the cap and form a seal with the cap. The rigid piston assembly can also include a retaining ring having a by-pass orifice. The retaining ring can be fixedly engaged to the piston seal. The retaining ring can include a plurality of channels.

A by-pass device having a body with a first end, a second end, and a passageway located within the body can be placed through the by-pass orifices of the rigid piston, the piston seal, and the retaining ring, thereby establishing fluid communication between the fluid inlet and an upper chamber formed between the rigid piston and the cap. When the upper chamber is relieved of pressure, fluid from the fluid inlet forces the rigid piston to axially move in a direction opposite the fluid outlet permitting fluid flow through the fluid outlet.

The rigid piston assembly can further include a fitting having a first end and a second end. The first end of the fitting can be connected to the cap, and a solenoid can be connected to the second end. A flow restricting element can be used to control the flow of water. An infrared sensor and a radio frequency chip can also be used with the rigid piston assembly. Further, a cover may be attached to the opening previously occupied by a handle member.

In accordance with another embodiment, a method of retrofitting a rigid piston into a flush valve having a diaphragm assembly generally includes removing the outer cover from the valve body, removing the diaphragm valve assembly from the valve body, removing the handle member assembly, inserting a rigid piston into the valve body, incorporating an adapter into the rigid piston, attaching a cap to the valve body at an end opposite the fluid outlet, inserting a first end of a fitting into the cap, and attaching a solenoid to the second end of the fitting. The rigid piston includes a piston seal attached to a portion of the rigid piston and a by-pass device positioned inside by-pass orifices located in the rigid piston and the piston seal. The rigid piston can also include a retaining ring. The retaining ring can have a by-pass orifice and the by-pass device can also be adapted to fit inside the by-pass orifice of the retaining ring. A flow restricting element, infrared sensor, and/or radio frequency chip can also be incorporated into the flush valve. Further, a cover may be attached to the opening previously occupied by a handle member. The method can further include placing a sealing component between the cap and valve body.

In accordance with yet another embodiment, a flush valve for a plumbing fixture includes a fluid inlet in fluid communication with a fluid source, a fluid outlet in fluid communication with a plumbing fixture, a cap positioned at an end opposite the fluid outlet, a piston valve for regulating fluid flow between the fluid inlet and the fluid outlet, a fitting having a first end and a second end where the first end of the fitting is attached to the cap, and a solenoid connected to the second end of the fitting. The flush valve can also include an infrared sensor and a radio frequency chip.

The piston valve includes a rigid piston with a central opening and a by-pass orifice. The rigid piston can further include guide members that maintain the alignment of the rigid piston within the valve during operation as well as a flow ring that gauges the amount of water to be flushed during operation. An adapter may be attached to the central opening of the rigid piston.

A piston seal having a by-pass orifice is fixedly engaged to the rigid piston and sealingly engaged to the valve body near an entrance of the fluid outlet. The piston seal can have an annular skirt that is adapted to extend out toward the cap and form a seal with the cap. The flush valve can also include a retaining ring. The retaining ring can include a plurality of channels.

A by-pass device having a body with a first end, a second end, and a passageway located within the body can be positioned inside the by-pass orifices of the rigid piston, the piston seal, and the retaining ring. The flush valve can also include a sealing component that forms a seal between the cap and the valve body.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional elevational view of an assembled diaphragm flush valve according to the prior art.

FIG. **2** is an exploded perspective view of the diaphragm flush valve according to FIG. **1**.

FIG. **3** is an exploded perspective view of one embodiment of a flush valve according to the present invention.

FIG. **4** is an exploded perspective view of one embodiment of a flush valve according to the present invention.

FIG. **5**A is a cross-sectional elevational view of a flush valve in a non-activated state according to the present invention.

FIG. **5**B is a cross-sectional elevational view of the flush valve of FIG. **5**A in an activated state according to the present invention.

FIG. **5**C is a cross-sectional elevational view of the flush valve of FIG. **5**A during a flushing event according to the present invention.

FIG. **6** is a cross-sectional bottom view of the flush valve according to the present invention.

FIG. **7** is a bottom view of a retaining ring according to one embodiment of the present invention.

FIG. **8** is a cross-sectional elevational view of a by-pass device according to the present invention.

FIG. **9** is a top view of a retaining ring according to one embodiment of the present invention.

FIG. **10** is a bottom view of the retaining ring of FIG. **9** according to the present invention.

FIG. **11** is a bottom isometric view of the retaining ring of FIG. **9** according to the present invention.

FIG. **12** is a top isometric view of the retaining ring of FIG. **9** according to the present invention.

FIG. **13** is a bottom perspective view of retaining ring of FIG. **9** attached to a piston seal according to the present invention.

DESCRIPTION OF THE INVENTION

For purposes of the description hereinafter, spatial orientation terms, if used, shall relate to the referenced embodiment as it is oriented in the accompanying drawing figures or otherwise described in the following description. However, it is to be understood that the embodiments described hereinafter may assume many alternative variations and embodiments. It is also to be understood that the specific devices illustrated in the accompanying figures and described herein are simply exemplary and should not be considered as limiting.

As shown in FIG. **1**, a conventional flush valve **2** has a general hollow valve body **10** which includes a fluid inlet **12**, a fluid outlet **14**, and a handle coupling connection **16**. The top of the valve body **10** is closed by an outer cover **18** and an inner cover **20**. The inlet portion of the valve is separated from the outlet portion by an outlet bore **22** which is attached to the inside of the valve body **10**. A main valve seat **24** is formed on the top of the outlet bore **22**.

The valve is actuated by an operating handle **26** which is fastened to the valve body **10** by means of a coupling nut **28**. The handle **26** is connected to a plunger **30** which extends to the interior portion of the valve body **10**. The plunger **30** is guided and supported by a bushing **32** and restored by a spring **34**. A rubber sealing cap or packing **36** is snapped on the end of bushing **32** and prevents leakage outward from the handle opening.

The main valve seat **24** is normally closed by a flexible rubber diaphragm **38**. The flexible rubber diaphragm **38** extends across the valve body **10** and defines an upper chamber **40**. The flexible rubber diaphragm **38** includes a by-pass hole **42** which provides fluid communication between the inlet side of the valve and the upper chamber **40**. A filter **44** may be provided thereover to prevent clogging of the by-pass hole **42**.

The flexible rubber diaphragm **38** is attached at its outer edge to the valve body **10**. The outer cover **18** clamps the flexible rubber diaphragm **38** to the valve body **10**. The center of the flexible rubber diaphragm **38** has an opening which allows fluid communication between the upper chamber **40** and the fluid outlet **14**. A relief valve shown generally at **46** is attached to the flexible rubber diaphragm **38** and normally closes the opening at the center of the flexible rubber diaphragm **38**. The relief valve **46** includes a guide portion **48** having wings **49**. The wings **49** fit closely against the inside diameter of the outlet bore **22**. The guide portion **48** also has a lip **50**. The lip **50** supports a collar **52**. The relief valve **46** includes a clamping member **54** which is threadably engaged with the guide portion **48**. The clamping member **54** clamps the inner edge of the flexible rubber diaphragm **38** between the clamping member **54** and the collar **52** to form a seal. The clamping member **54** has a hole in the middle which is normally closed by an auxiliary valve member **56**. This auxiliary member **56** is connected to a depending stem **58** which extends to a point opposite the actuating plunger **30**.

Referring specifically to FIG. **2**, a central throat **23** is first placed into the valve body **10**. A guide ring **70** is placed around a top portion of the central throat **23**, and a flow ring **72** is placed on top of the guide ring **70**. The flexible rubber diaphragm **38** is then placed into the valve body **10**. A by-pass hole **42** is positioned in the flexible rubber diaphragm **38** and a molded disc **74** is placed onto the flexible rubber diaphragm **38**. The relief valve **46** is placed through openings located in the center of the molded disc **74** and flexible rubber diaphragm **38**. An inner cover **20** is placed over the diaphragm assembly and an outer cover **18** is placed on top of the inner cover **20**. As discussed in detail above, flush valves incorporating a flexible rubber diaphragm **38** have numerous drawbacks. Accordingly, the present invention is directed to a rigid piston **310** incorporating a solenoid **400**, as shown in FIG. **3**, for use in a conventional flush valve body **10**.

As shown in FIGS. **3-4**, the present invention includes a rigid piston **310** having a disc shaped member **306** defining a central opening **313** therein and an elongated hollow member **308** that extends from the disc shaped member **306** of the rigid piston **310**. The rigid piston **310** can also have a by-pass orifice **312** defined in the disc shaped member **306** of the rigid piston **310**. The rigid piston **310** sits directly within the hollow valve body **10** providing a mechanism for regulating water flow through the valve body **10**.

When placed into the valve body **10**, the disc shaped member **306** of the rigid piston **310** sits on top of a central valve seat **124** of the outlet bore **22** and the elongated hollow member **308** extends down into the outlet bore **22**. The disc shaped member **306** extends outward from the central seat **124** of the outlet bore **22** to an inside annular shoulder **116** of the valve body **10** creating a lower chamber **158** and an upper chamber **160**, as shown in FIG. **5**A. The lower chamber **158**, located below the disc shaped member **306** of the rigid piston **310** near the fluid inlet **12**, is defined between the rigid piston **310**, outlet bore **22**, and valve body **10**. The upper chamber **160**, located above the disc shaped member **306** of the rigid piston **310**, is defined between the rigid piston **310**, the valve body **10**, and a cylindrical cap **120** that is attached to the valve body **10** at an end opposite the fluid outlet **14**.

The rigid piston **310** can have a scallop shaped flow ring **314** for maintaining a constant water flow area, such as shown in FIGS. **4** and **6**. The flow ring **314** can be attached to the outer surface of the elongated hollow member **308** of the rigid piston **310**. During flushing, water flows around the flow ring **314** as it enters the outlet bore **22**. The flow ring **314** helps regulate the flow of water during flushing, which allows for a consistent turbulent flow of water during flushing when the rigid piston **310** is incorporated into the valve body **10**. A consistent turbulent flow of water through the throat of a toilet helps ensure proper flushing with a sufficient amount of water. The flow ring **314** also ensures a high velocity of flush which allows for a quicker and more efficient flush.

Guide members **316** can also be attached to the elongated hollow member **308** of the rigid piston **310** (see FIGS. **3-4**). The guide members **316** extend down the length of the elongated hollow member **308** of the rigid piston **310**. When the rigid piston **310** is placed into the valve body **10**, the guide members **316** abut the inside wall of the outlet bore **22** securing the elongated hollow member **308** of the rigid piston **310** within the valve body **10**. The guide members **316** ride along the inside wall of the outlet bore **22** as the rigid piston **310** moves during operation. This prevents the rigid piston **310** from shifting during operation, thereby maintaining proper alignment of the rigid piston **310** within the valve body **10** at all times. In one embodiment, the flow ring **314** is also attached to the guide members **316**.

Referring to FIGS. **3-4**, a piston seal **140** can be attached to the rigid piston **310**. As shown in FIG. **4**, the piston seal **140** can have a central opening **147** for receiving the elongated hollow member **308** of the rigid piston **310**. The piston seal **140** can also have a by-pass orifice **142**. The piston seal **140** can be made of an elastomeric material such as rubber. The piston seal **140** is configured to fixedly engage with the rigid piston **310**. For example, as shown in FIG. **4**, an undersurface **311** of the disc shaped member **306** of the rigid piston **310** can be adapted to fixedly engage with a sealing surface **141** of the piston seal **140**. In one embodiment, as shown in FIG. **4**, the undersurface **311** of the disc shaped member **306** of the rigid piston **310** may define cavities and the piston seal **140** may include corresponding projections **126**, such as barbed projections, that can be placed into the cavities of the rigid piston **310**, thereby securing the piston seal **140** to the rigid piston **310**. In certain embodiments, the piston seal **140** is molded to the rigid piston **310**. The piston seal **140** can further have an annular skirt **128** that completely surrounds the outer edge of the piston seal **140** (See FIG. **4**).

The piston seal **140** is sized and shaped to engage and form a seal with the valve body **10**. In one embodiment, the piston seal **140** is designed to engage and form a first seal with the central valve seat **124** of the outlet bore **22** and a second seal with a cap **120** that is attached to the valve body **10** after the rigid piston **310** is inserted into the valve body **10**. For instance, once the piston seal **140** is attached to the rigid piston **310**, the rigid piston **310** and piston seal **140** can be placed into the valve body **10**. A central sealing ring **143** extending from the piston seal **140** can be placed into the outlet bore **22** of the valve body **10** (see FIG. **4**). This engagement forms a first seal around the central valve seat **124** of the outlet bore **22** shown in FIG. **3**. This helps prevent water from leaking into the fluid outlet **14** from the fluid inlet **12**.

The annular skirt **128** of the piston seal **140** can engage the inside of a cylindrical cap **120** that is attached to the valve body **10** at an end opposite the fluid outlet **14**. For example, the annular skirt **128** may include a sealing edge **129** located at the bottom end of the annular skirt **128** shown in FIG. **4**. As water flows through the fluid inlet **12** into the lower chamber **158** (see FIG. **5**A), water pushes up on the piston seal **140**. The pressure forces the annular skirt **128** surrounding the piston seal **140** to extend out toward the cylindrical cap **120** attached to the valve body **10**. The sealing edge **129** of the annular skirt **128** contacts the inside of the cylindrical cap **120** and forms a seal between the piston seal **140** and the cylindrical cap **120**. This second sealing engagement prevents water in the lower chamber **158** from leaking around the outer portion of the rigid piston **310** into the upper chamber **160**.

The dual sealing arrangement described above makes it possible to form separate and distinct seals at two different areas in a flush valve body **10** at the same time with a single piston seal **140**. The use of a single sealing member to form multiple sealing engagements in different areas at the same time, allows for an efficient sealing arrangement in a flush valve body **10**. It also allows for an easy and fast installation process.

Referring to FIGS. **3-4**, the piston assembly can further include a retaining ring **90**, **290**. In certain embodiments, as shown in FIG. **4**, the retaining ring **90** includes a by-pass orifice **92** and a central opening **91** that can receive the elongated hollow member **308** of the rigid piston **310**. Alternatively, as shown in FIG. **3**, the retaining ring **290** is smaller in size and does not have a central opening **91** to receive the elongated hollow member **308** of the rigid piston **310**. FIGS. **9-12** show enlarged images of the smaller retaining ring **290** that does not have a central opening **91** to receive the elongated hollow member **308** of the rigid piston **310**. As shown in FIGS. **9-12**, the smaller retaining ring **290** still contains the by-pass orifice **92**.

In certain embodiments, the retaining ring **90**, **290** can be fixedly engaged to the piston seal **140**. For example, in one embodiment shown in FIG. **4**, the retaining ring **90** has a plurality of projections **114** that can be placed into corresponding cavities located in the piston seal **140**, thereby securing the retaining ring **90** to the piston seal **140**. Alternatively, as shown in FIG. **13**, the piston seal **140** contains protrusions **139** that can be placed through receiving holes **291**, as shown in FIGS. **9-12**, in the retaining ring **290**. Further, as shown in FIGS. **7** and **9-13**, the retaining ring **90**, **290** may include a plurality of channels **94** that are small in diameter, preventing large debris from entering the channels **94**.

In accordance with one embodiment of the present invention, as shown in FIGS. **3-4**, a by-pass device **300** can be placed through the by-pass orifices **312**, **142** of the rigid piston **310** and the piston seal **140**. The by-pass device **300** includes a body having a first end **302** and a second end **304** (see FIGS. **3-4**). The second end **304** of the by-pass device **300** can be placed through the by-pass orifice **312** defined in the rigid piston **310**, and the first end **302** of the by-pass device **300** can be placed through the by-pass orifice **142** defined in the piston seal **140**. Referring to FIGS. **3-4**, in certain embodiments, when a retaining ring **90**, **290** is used, the first end **302** of the by-pass device **300** also can be placed through a by-pass orifice **92** defined in the retaining ring **90**, **290**.

As shown in FIG. **8**, the by-pass device **300** further contains a passageway **301** formed within the body of the by-pass device **300**. This passageway **301** connects the lower chamber **158** near the fluid inlet **12** to the upper chamber **160** located above the rigid piston **310**. The passageway **301** of the by-pass device **300** is designed so that water can enter through at least one opening located near the first end **302** of the by-pass device **300**. The water can then flow from the opening(s) located near the first end **302**, through the passageway **301**, and out an opening located at the second end **304** of the by-pass device **300**. Reference letter "B" in FIG. **8** illustrates the flow of water from the lower chamber **158** to the upper chamber **160** by way of the passageway **301** of the by-pass device **300**.

During assembly of one embodiment according to the present invention, the second end **304** of the by-pass device **300** is placed through the by-pass orifice **312** of the rigid piston **310**. The piston seal **140** is attached to the rigid piston **310** with the first end **302** of the by-pass device **300** being placed through the by-pass orifice **142** of the piston seal **140**. Once placed into the valve body **10**, the piston seal **140** forms a seal with the central valve seat **124** of the outlet bore **22** and the cap **120** that is attached to the valve body **10** after the rigid piston **310** is placed into the valve body **10**. This prevents water from entering the fluid outlet **14** and the upper chamber **160** as described above. As a result, water from the fluid inlet **12** can only enter the upper chamber **160** through the by-pass device **300**.

In certain embodiments, as shown in FIGS. **3-4**, a retaining ring **90**, **290** can be attached to the piston seal **140** and the first end **302** of the by-pass device **300** can be placed through the by-pass orifice **92** of the retaining ring **90**, **290**. FIG. **7** shows a bottom view of a by-pass device **300** being placed through the by-pass orifice of a retaining ring **90**. As shown in FIG. **8**, water flows through the channels **94** located in the retaining ring **90** and into the opening(s) located near the first end **302** of the by-pass device **300**, which then flows out the second end **304** of the by-pass device **300** and into the upper chamber **160**. The channels **94** are smaller in diameter than the passageway **301** of the by-pass device **300**. This filters out large debris, thereby preventing clogging of the passageway **301** of the by-pass device **300**.

Referring to FIG. **3**, the present invention can further include an adapter **220** that can be positioned in the rigid piston **310** and extend into the elongated hollow member **308** of the rigid piston **310**. As shown in FIG. **5**A, the adapter **220** engages and forms a seal with the rigid piston **310** around the opening located in the center of the rigid piston **310**. This seal prevents water in the upper chamber **160** from leaking between the adapter **220** and rigid piston **310** and into the fluid outlet **14**. In certain embodiments, the adapter **220** is molded to the rigid piston **310**.

Referring to FIG. **3**, a cylindrical cap **120** is placed onto the valve body **10** after the rigid piston **310** and adapter **220** are installed into the flush valve body **10**. The cylindrical cap **120** is placed onto the valve body **10** next to the rigid piston **310**. The cap **120** can be made of any rigid material including various types of plastics and metals. In addition, the surface of the cap **120** contains the required lubricity to easily slide onto the valve body **10**. Once inserted onto the valve body **10**, the cylindrical cap **120** further secures the piston **310** in place and functions as a mechanism limiting the movement of the piston **310** to a consistently steady axial motion within the valve body **10**.

A sealing component **380**, such as an O-ring or gasket, can be positioned into the valve body **10** next to the rigid piston **310**. When the cap **120** is inserted onto the valve body **10**, pressure is applied to the sealing component **380** contained therein, thereby forming a tight seal between the valve body **10** and the cylindrical cap **120**.

As shown in FIGS. **5**A-**5**C, the cylindrical cap **120** includes a hollow stem **122** that extends down from the cap **120**. In certain embodiments, the cylindrical cap **120** also includes a collar **121**. The hollow stem **122** extends into the adapter **220** positioned in the rigid piston **310**. Once placed into the adapter **220**, the hollow stem **122** forms two seals with the adapter **220**. A first seal **150** is formed between the hollow stem **122** and adapter **220** near the cylindrical cap **120**, and a secondary seal **152** is formed between the hollow stem **122** and adapter **220** at a location below the first seal **150** (see FIG. **5**C). This dual seal engagement prevents water in the upper chamber **160** from leaking between the hollow stem **122** and adapter **220** and into the fluid outlet **14**.

In certain embodiments, as shown in FIGS. **5**A-**5**C, a fitting **240**, such as a bleed plug, can be used to connect a solenoid **400** to the flush valve **2**. Referring to FIG. **3**, the fitting **240** has a first end **242** and a second end **244**. The first end **242** of the fitting **240** is connectable to the flush valve **2**, such as to the collar **121** of the cap **120**, and the second end **244** is configured to receive a solenoid **400**. For instance, in certain embodiments as shown in FIG. **3**, the first end **242** of the fitting **240** can have external threads and can be threadably connected to the collar **121** of the cap **120**, and the second end **244** of the cap **120** can have internal threads to receive external threads on the solenoid **400**.

As indicated above, in certain embodiments as shown in FIGS. **5**A-**5**C, a solenoid **400** is attached to the fitting **240** that, in turn, is attached to the collar **121** of the cap **120**. The solenoid **400** includes a solenoid plunger **402** that is slidable within the solenoid **400**, as is conventional in many solenoids. The solenoid plunger **402** engages the inside portion of the fitting **240**. The solenoid **400** allows the flush valve **2** to be controlled electronically, such as by a conventional push-button actuator. In certain embodiments, the solenoid **400** is activated by an infrared (IR) sensor. A radio frequency (RF) chip can also be built into the flush valve **2** for wireless communication with a controller. As such, the operating handle **26** assembly previously used is removed from the flush valve body **10**. As shown in FIG. **3**, a cover **420** such as a cap can be placed over the opening where the operating handle **26** assembly was removed. A sealing member **422**, such as a washer, can be used with the cover **420**.

Referring to FIG. **3**, in certain embodiments, a flow restricting element **440** is positioned within the flush valve **2**. The flow restricting element **440** controls the flow of water during operation. As shown in FIGS. **5A-5C**, in certain embodiments, the flow restricting element **440** is positioned in the hollow stem **122** of the cap **120**.

FIG. **5A** shows the piston assembly according to one embodiment of the present invention incorporated into the valve body **10** while the flush valve **2** is in a closed steady-state position. The piston seal **140** attached to the rigid piston **310** engages the central valve seat **124** of the outlet bore **22**. Water flowing into the fluid inlet **12** passes through the passageway **301** of the by-pass device **300**, and into the upper chamber **160**. Water is then channeled through a passage **123** in the cap **120**, through cavities in the fitting **240**, and up to the solenoid **400**. Because the solenoid plunger **402** is in a sealed position within the fitting **240**, water is not allowed to flow through the hollow stem **122** of the cap **120**.

As shown in FIG. **5A**, the adapter **220** and hollow stem **122** of the cap **120** close the opening in the center of the rigid piston **310** preventing water from entering the central opening **313**. The pressure in the upper chamber **160** forces the piston **310** down onto the piston seal **140**, which forces the piston seal **140** onto the central valve seat **124** forming a seal around the outlet bore **22** so that there is no fluid communication between the fluid inlet **12** and fluid outlet **14**. Pressure from water flowing through the fluid inlet **12** causes the annular skirt **128**, as shown in FIGS. **3-4**, to extend outward onto the inside of the cylindrical cap **120**, as shown in FIG. **3**. This prevents water in the lower chamber **158** from entering the upper chamber **160**.

In operation, as shown in FIG. **5B**, when actuated, the solenoid plunger **402** lifts off the fitting **240**. This allows water to flow through the flow restricting element **440** and hollow stem **121**, thereby relieving pressure from the upper chamber **160**. The solenoid **400** remains actuated for a set period of time. The set period of time and the flow restricting element **440** help control the amount of water that flows to the fluid outlet **14**.

Referring to FIG. **5C**, as pressure is relieved from the upper chamber **160**, inlet water pressure forces the piston **310** to move axially upwards off of the central valve seat **124** in a direction opposite the fluid outlet **14**. The guide members **316** attached to the elongated hollow member **308** of the rigid piston **310** ride along the inside wall of the outlet bore **22** maintaining proper alignment of the rigid piston **310** as it moves off the central valve seat **124**.

During flushing, as shown in FIG. **5C**, water flows directly from the fluid inlet **12** into the flow ring **314**, which gauges the proper amount of volume to be flushed. The water then continues to the fluid outlet **14** in the direction shown by reference letter "A" in FIG. **5C**. As the valve is flushing, the water pressure pushing the rigid piston **310** off the central valve seat **124** is continuing to act on the annular skirt **128** of the piston seal **140**. This pressure pushes the annular skirt **128** out towards the cap **120** that is attached to the valve body **10**. This maintains a seal between the lower chamber **158** and upper chamber **160** so that water can only enter the upper chamber **160** through the by-pass device **300**. As discussed above, the hollow stem **122** forms two seals with the adapter **220**. A first seal **150** is formed between the hollow stem **122** and adapter **220** near the cylindrical cap **120**, and a secondary seal **152** is formed between the hollow stem **122** and adapter **220** at a location below the first seal **150**. If the first seal **150** is broken, the secondary seal **152** maintains the sealing engagement between the hollow stem **122** and adapter **220**.

As water flows from the inlet **12** into the outlet **14**, water is also flowing through the by-pass device **300** into the upper chamber **160**. When the water pressure in the upper chamber **160** is greater than the inlet **12** water pressure, the rigid piston **310** and piston seal **140** are forced back onto the central valve seat **124** in a steady axial motion with the help of the guide members **316** so that there is no fluid communication between the inlet **12** and outlet **14**.

The present invention is also directed to a method of retrofitting a rigid piston **310** into a flush valve body **10**. Referring to FIGS. **2-4**, the method includes removing the outer cover **18** from the diaphragm flush valve **2**, and then removing the diaphragm valve assembly and operating handle **26** assembly from the valve body **10**. Next, the rigid piston **310** and piston seal **140** are attached to each other with the by-pass device **300** placed within by-pass orifices **312**, **142** defined in the rigid piston **310** and piston seal **140**. In one embodiment, a retaining ring **90**, **290** is attached to the piston seal **140** and the by-pass device **300** is also placed within a by-pass orifice **92** defined in the retaining ring **90**, **290**.

The rigid piston **310** is axially mounted into the valve body **10** and onto the central valve seat **124** of the outlet bore **22**. After mounting the rigid piston **310** into the valve body **10**, the adapter **220** is incorporated into the rigid piston **310**. The cylindrical cap **120** is attached to the valve body **10** at an end opposite the flow outlet **14** with the hollow stem **122** extending into the adapter **220**. A sealing component **380**, such as an O-ring, may also be placed into the flush valve body **10** with the cylindrical cap **120**. Once placed into the adapter **220**, the hollow stem **122** forms two seals with the adapter **220**. In certain embodiments, a flow restricting element **440** is placed into the hollow stem **122**. The first end **242** of a fitting **240**, such as a bleed plug, is connected to the collar **121** of the cap **120**. A solenoid **400** is then connected to the second end **244** of the fitting **240**. Finally, a cover **420** can be placed over the opening where the operating handle **26** assembly was removed. A sealing member **422**, such as a washer, can be used with the cover **420**.

Accordingly, the present invention, which is directed to a rigid piston **310** incorporating a solenoid **400** that can be used in a conventional flush valve body **10**, provides a more efficient flush that is electronically controlled. Because the by-pass orifice **312** is larger and the rigid piston **310** moves with a consistently steady axial movement, less water is used during the flush cycle. Further still, the present invention can easily be retrofitted into a conventional flush valve body **10** allowing for a fast and cheap installation process.

While several embodiments of the invention were described in the foregoing detailed description, those skilled in the art may make modifications and alterations to these embodiments without departing from the scope and spirit of the invention. Accordingly, the foregoing description is intended to be illustrative rather than restrictive.

The invention claimed is:

1. A method of retrofitting a rigid piston and a solenoid into a flush valve, the flush valve having a valve body with a fluid inlet, a fluid outlet, a diaphragm valve assembly, an outer cover, and a handle member, the method comprising the steps of:

a) removing the outer cover from the valve body;

b) removing the diaphragm valve assembly from the valve body;

c) removing the actuating rod assembly from the valve body;

d) inserting a rigid piston into the valve body, the rigid piston comprising a disc shaped member having a central opening, an elongated hollow member that is attached to and extends down from the disc shaped member, and a piston seal attached directly to at least a portion of the disc shaped member, wherein the rigid piston is adapted to move axially in the direction of the flow of water from the fluid inlet to the fluid outlet;

e) attaching a cap to the valve body at an end opposite the fluid outlet, the cap having a hollow stem extending down from a central opening of the cap;

f) inserting a first end of a fitting into the cap; and

g) attaching a solenoid to the second end of the fitting, and wherein the piston seal comprises an annular skirt surrounding an outer edge of the piston seal that is adapted to expand out toward the top closure connected to the valve body and form a seal with the top closure.

2. The method according to claim **1**, wherein the rigid piston is placed on top of a central valve seat such that the elongated hollow member extends down into an outlet bore of the flush valve.

3. The method according to claim **1**, wherein the annular skirt extends around an outside perimeter of both the piston seal and the disc shaped member.

4. The method according to claim **1**, wherein the piston seal comprises a disc shaped body with a central opening and the annular skirt extends around an outer edge of the disc shaped body.

5. The method according to claim **4**, wherein at least a portion of the disc shaped body of the piston seal is attached to at least a portion of the disc shaped member of the rigid piston.

6. The method according to claim **1**, further comprising incorporating an adapter into the central opening of the disc shaped member of the rigid piston, and wherein the hollow stem of the cap is placed through an opening in the adapter.

7. The method according to claim **6**, wherein a dual sealing engagement is formed between the hollow stem and the adapter.

8. The method according to claim **1**, further comprising attaching a flow restricting element into the hollow stem of the cap.

9. The method according to claim **1**, further comprising attaching a cover to the opening previously occupied by an actuating rod assembly.

10. The method according to claim **1**, further comprising placing a sealing component between the cap and the valve body.

11. The method according to claim **1**, wherein the rigid piston further comprises guide members that maintain the alignment of the rigid piston within the valve body during operation.

12. The method according to claim **11**, wherein the guide members extend out from the elongated hollow member.

13. The method according to claim **1**, wherein the rigid piston further comprises a flow ring that gauges the amount of water to be flushed during operation.

14. The method according to claim **13**, wherein the flow ring is positioned below the disc shaped member of the rigid piston.

15. The method according to claim **14**, wherein the flow ring is attached to the elongated hollow member of the rigid piston.

16. The method according to claim **1**, further comprising incorporating an infrared sensor.

17. The method according to claim **1**, further comprising incorporating a radio frequency chip.

18. The method according to claim **1**, wherein the piston seal is formed from a single rubber article.

19. The method according to claim **1**, wherein the disc shaped member of the rigid piston comprises a by-pass orifice.

20. The method according to claim **19**, wherein the piston seal comprises a by-pass orifice that is aligned with the by-pass orifice of the disc shaped member of the rigid piston.

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